Prevalence and causes of anemia in the United States, 1976 to 1980[1,2]

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ABSTRACT We estimated the prevalence of anemia in the United States from the results of the Second National Health and Nutrition Examination Survey (NHANES II, 1976 to 1980). Reference ranges for Hb were first derived from 11,547 subjects in whom laboratory values for serum iron/iron-binding capacity, mean corpuscular volume, and erythrocyte protoporphyrin were all normal (≥ 16%, ≥ 80 fl, and ≤ 75 μg/dl red blood cells, respectively). Using these reference standards, the prevalence of anemia (Hb values below the 95% reference range for age and sex) among the 15,093 subjects with complete laboratory results was highest in infants (5.7%), teenage girls (5.9%), young women (5.8%), and elderly men (4.4%). The pattern of laboratory abnormalities in anemic subjects indicated that iron deficiency predominated as a cause in infants and young women in contrast to inflammatory disease in the elderly. *Am J Clin Nutr* 1984;39:437–445.

KEY WORDS Anemia, iron-deficiency hemoglobin, prevalence of anemia, hemoglobin reference ranges

Introduction

The results of the second National Health and Nutrition Examination Survey (NHANES II) provide adequate data on which to base estimates of the prevalence of iron-deficiency anemia and the anemia of inflammatory disease (1). The survey included a carefully selected, representative sample of the population in the United States. An edited data tape for the laboratory analyses that are relevant to iron deficiency (2, 3) became available in August 1982, and some of the results were tabulated in a publication that appeared later in the year (1). Further information necessary to identify values from pregnant women and individuals with hemoglobinopathies were ready for analysis in January 1983. Values for serum ferritin on a subpopulation of 5157 subjects were used in certain of the analyses.

The prevalence of anemia is usually defined in terms of the percentage of individuals with Hb values below a 95% reference range. We derived 95% reference ranges for Hb concentration from NHANES II because this large and carefully conducted survey offered the prospects of providing a stronger basis for reference values than previously available. For this purpose, we included only those subjects who had venous blood samples and excluded all subjects with pregnancy, hemoglobinopathies, or an abnormality in iron/total iron-binding capacity (Fe/TIBC), mean corpuscular Hb (MCV), or erythrocyte protoporphyrin (EP). These reference ranges were then used as a basis for estimates of the prevalence of anemia, ie, the percentage of individuals with Hb values below the 95% reference range for age and sex.

Anemia can also be considered in terms of the *depression* of Hb concentration by the presence of common abnormalities such as iron deficiency or inflammatory disease (in which laboratory abnormalities are similar), even if that depression occurs within the "normal" reference range. The relative prev-

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alence of anemia defined in this manner was estimated from the degree to which the frequency distribution for Hb concentration shifted toward higher values after exclusion of subjects who had one or more laboratory values indicative of iron deficiency and/or inflammatory disease.

Because of the sophisticated population sampling used in NHANES II, it is reasonable to extrapolate from the prevalence of anemia in the survey data to the prevalence in the United States.

Methods

The NHANES II sample design

NHANES II was conducted between 1976 and 1980 by the National Center for Health Statistics. A detailed description of the survey design has been previously published (4). The protocol for the study of human subjects was approved. A total of 27,801 persons from 64 sampling areas was selected in the probability sample as representative of the United States civilian population 6 months through 74 yr old who were not institutionalized. Certain subgroups in the population that were of special interest for nutritional assessment were oversampled: preschool children (6 months through 5 yr old), persons 60 through 74 yr old, and the poor (persons living in areas defined as poor by the United States Bureau of the Census for the 1970 census). The United States Bureau of the Census selected the NHANES II sample according to rigorous specifications from the National Center for Health Statistics so that the probability of selection for each person in the sample could be determined. Of the 27,801 persons in the probability sample, 20,322 individuals were examined. Of the 20,322 examined individuals, 18,981 had Hb determinations. For the purposes of this report, we excluded 725 subjects from the latter group because of pregnancy (n = 120), abnormal Hb electrophoresis (n = 313: primarily Hb AS, 155; AC, 50; elevated F, 43; and elevated A_2, 30), or because only skin puncture blood could be obtained (n = 292). These exclusions involved primarily young women (pregnancy), Blacks (hemoglobinopathies), and children under the age of 5 yr (skin puncture blood). Of the remaining 18,256, 15,115 had no missing laboratory values for Fe/TIBC, MCV, or EP. From the group with no missing laboratory values we excluded the 22 infants between ages of 6 and 11 months because of the small number in this age group and the marked changes in iron status during this period (3). The remaining group of 15,093 subjects was the basis for **Tables 1 and 2. Table 3** was based on those 11,547 of the 15,093 subjects who had normal values for Fe/TIBC, MCV, and EP by criteria that will be described below. **Figures 1*A* and 2** involve a comparison of the 15,093 subjects of all races who had complete sets of data with the subgroup of 11,547 subjects in whom values for Fe/TIBC, MCV, and Ep were all normal. **Figure 1*B*** and a portion of Figure 2 are similarly based on comparing the 13,105 whites with complete sets of data with the subgroup of 10,168 whites in whom values for Fe/TIBC, MCV, and EP were all normal.

The statistics presented in this report are population estimates. Although Tables 1 and 3 and **Figure 3** show actual numbers of subjects, the laboratory findings for each person in the sample were inflated by the reciprocal of selection probabilities, adjusted to account for persons who were not examined, and stratified afterward according to race, sex, and age, so that the final calculated values should be representative of the civilian noninstitutionalized population of the United States as estimated independently by the United States Bureau of the Census at the midpoint of the survey, March 1, 1978 (4).

Laboratory analyses (1)

Venipuncture blood was collected into tubes containing EDTA for analysis of Hb, hematocrit, red cell indices, and EP. Fe and TIBC were determined in serum that was promptly separated from the clot after centrifugation for 10 min at 1060 × *g*.

All quality control procedures and detailed methods for the hematological and chemical studies are described elsewhere (1, 5). Hb concentration was determined by the cyanmethemoglobin method. Hematocrit was measured from the volume of erythrocytes as a percentage of the total sample volume after centrifugation of heparinized capillary tubes. Red cell number and indices were measured by electronic counter (Coulter, Hialeah, FL, Model FN with Coulter Dilutor III). MCV was calculated from the ratio of the microhematocrit divided by the red cell number. EP was measured fluorometrically. Fe and TIBC were determined by an automated spectrophotometric procedure. Fe, TIBC, and EP were analyzed in the laboratories of the Centers for Disease Control in Atlanta, GA. Serum ferritin was measured by radioimmunoassay (6) in the laboratory of Dr James Cook on a subsample of 5157 subjects between the ages of 3 and 74 yr, which included all those who were anemic, as well as a 10% sample of all other subjects (5).

Derivation of reference values for concentration of Hb

The numerous laboratory studies that were performed in NHANES II provided an opportunity for generating reference standards for Hb on a screened population. Iron deficiency and inflammatory disease are thought to be the most common causes of anemia (2, 3) and both are characterized by a decrease in Fe/TIBC and MCV and by an increase in EP. An individual with one or more of these abnormalities was considered suspect and was excluded from the Hb reference population. We excluded suspect individuals from the reference population on the basis of laboratory criteria that are used for the diagnosis of iron deficiency in adults (or for all ages in the case of EP): Fe/TIBC <16% (2, 7), MCV <80 fl (7), or EP >75 μg/dl red blood cells (2, 7). Among adults, the percentage of individuals excluded by these criteria ranged from a low value of 8.8% in men and between 25 and 44 yr to a high value of 21.7% in women between 25 and 44 yr of age. The criteria used in adults and older children could not be applied to infants because of the substantial normal

TABLE 1
Prevalence of anemia: percentage of values for all races (AR) and whites (W) below the 95% reference ranges for AR and W, respectively, (shown in Table 3), by age and sex

Age (yr)		1–2	3–5	6–8	9–11	12–14	15–17	18–24	25–44	45–64	65–74
Males and females	AR	5.7	3.5	2.3	2.8						
	W		2.3	1.5	2.5						
Males	AR					2.9	2.6	2.7	2.9	3.8	4.4
	W					2.2	2.2	3.0	2.9	3.4	4.5
Females	AR					3.6	5.9	3.3	5.8	3.9	3.9
	W					3.7	4.3	3.0	4.6	3.7	3.5

TABLE 2
Laboratory characteristics of anemic and nonanemic infants, young women, and elderly men (all races); anemia is defined as a value below the 95% range for all races shown in Table 3

Group: age (yr)	n	Fe*	TIBC*	Fe/TIBC	MCV	EP*	Ferritin	
		μg/dl	*μg/dl*	*%*	*fl*	*μg/dl red blood cells*	*n*	*μg/dl*
Infants: 1–2								
Anemic	26	57.8†	445†	13.0†	74.9†	126.1†		
Nonanemic	405	81.3	408	20.2	78.6	67.3		
Women: 25–44								
Anemic	88	75.8†	392†	20.4†	87.5†	71.6†	66	14.9†
Nonanemic	1594	99.8	375	27.1	90.2	54.4	472	29.9
Men: 65–74								
Anemic	53	84.9†	355	25.4†	91.1	79.4†	50	90.9
Nonanemic	960	101.2	348	29.5	91.0	51.2	296	93.8

* To convert to international system of units (SI), multiply Fe and TIBC values by 0.179 to obtain mol/l and multiply EP values by 10 to obtain μg/l red blood cells.

† Anemic group differs from non anemic, $p < 0.01$; all other differences are not significant, $p < 0.05$.

developmental differences in Fe/TIBC and MCV (8, 9). Because these criteria are relatively stringent, they should also be expected to result in the exclusion of some healthy individuals. For infants 1 to 2 yr of age, we excluded any subject with a value for Fe/TIBC, MCV, *or* EP that was in the most abnormal 10% for that group.

We did not attempt to make a correction for altitude. Only one of the 64 sampling areas (Laramie, WY) was at an elevation above 1000 m and we did not believe that the suggested correction factors for the effect of altitude on Hb concentration were precisely enough established to apply with confidence to the NHANES II data.

Estimation of relative prevalence of a depression in Hb concentration due to iron deficiency and inflammatory disease

We estimated the relative prevalence of depressed Hb values due to iron deficiency or inflammatory disease by determining the shift in the median Hb concentration (50th percentile) after excluding individuals with low values for Fe/TIBC and MCV and high values for EP, as shown in Figure 1. Using the 50th percentile to calculate relative prevalence has the advantage of including individuals in the lower half of the Hb (or hematocrit) distribution, where overlap between normal values and those influenced by iron deficiency is greatest (10). We performed these calculations by using the criteria described above. We use the term, relative prevalence to indicate that the values are merely estimates and that they are most useful in comparing prevalence according to age and sex. An example of the calculation of relative prevalence is as follows: in women between 25 and 34 yr of age, the 50th percentile for Hb concentration shifted from 13.29 to 13.41 g/dl after excluding individuals on the basis of the above mentioned laboratory criteria. The new value of 13.41 g/dl now corresponded to the 54.6th percentile of the original unscreened group, representing a shift of 4.6 percentiles or a relative prevalence of 4.6%.

We intentionally focused on iron deficiency in terms of its effects on Hb concentration since there is little convincing evidence that depletion of storage iron has adverse health consequences if the Hb concentration has not been affected (11). Furthermore, the borderline between depletion of storage iron and the normally marginal state of iron stores in infants, children, and young women may be arbitrary or difficult to define.

Statistical analyses

Reference ranges were derived only from groups in which the sample size exceeded 200, based on an extrapolation from a recent report in which the minimum numbers for which reliable estimates of the 5th and 95th percentiles could be obtained was listed as 100 and

TABLE 3
Concentration of venous Hb (g/dl) by age, sex, and race after excluding pregnant women, subjects with hemoglobinopathies and individuals with Fe/TIBC <16%, MCV <80 fl, *or* EP >75 μg/dl red blood cells

Race	Age	Males n	Males Median*	Males 95% range†	Females n	Females Median	Females 95% range
	yr						
All races							
	1–2‡	63	12.3	(10.7–13.8)	59	12.3	(10.7–13.8)
	3–5‡	301	12.5	10.9–14.4	286	12.5	10.9–14.4
	6–8‡	152	12.8	11.0–14.3	163	12.8	11.0–14.3
	9–11‡	215	13.2	11.4–14.8	215	13.2	11.4–14.8
	12–14	278	14.0	12.0–16.0	299	13.4	11.5–15.0
	15–17	371	14.8	12.3–16.6	260	13.5	11.7–15.3
	18–44	2195	15.3	13.2–17.3	1999	13.5	11.7–15.5
	45–64	1433	15.2	13.1–17.2	1400	13.7	11.7–16.0
	65–74	884	14.9	12.6–17.4	974	13.8	11.7–16.1
White							
	1–2‡	50	12.2		48	12.2	
	3–5‡	254	12.5	10.9–14.5	242	12.5	10.9–14.5
	6–8‡	133	12.8	11.0–14.3	134	12.8	11.0–14.3
	9–11‡	187	13.3	11.6–14.8	182	13.3	11.6–14.8
	12–14	242	14.0	12.0–16.0	253	13.4	11.7–15.0
	15–17	308	14.9	13.1–16.5	229	13.5	11.7–15.4
	18–44	1914	15.3	13.4–17.3	1745	13.6	11.9–15.5
	45–64	1295	15.2	13.2–17.2	1273	13.8	11.8–16.0
	65–74	795	14.9	12.6–17.5	884	13.9	11.9–16.1
Black							
	1–2‡	8			3		
	3–5‡	36	12.1		35	12.1	
	6–8‡	16	(12.6)		23	(12.6)	
	9–11‡	25	12.4		28	12.4	
	12–14	31	(13.1)		42	(13.0)	
	15–17	52	13.9		26	(12.8)	
	18–44	227	14.5	12.3–16.7	216	12.8	10.7–15.3
	45–64	117	14.2	(12.6–16.1)	110	13.0	(11.2–15.1)
	65–74	68	13.8		80	13.0	

* Medians on groups of 20 to 50 are shown in parentheses; results on smaller groups were not tabulated.
† Ranges on groups of 100 to 200 are shown in parentheses; results in smaller groups were not tabulated.
‡ Sexes were combined for calculation of medians and ranges in children under 11 yr of age.

the corresponding number for the 10th and 90th percentiles was 50 (1).

Computations were performed using the table producing program of the United States Department of Labor Bureau of Labor Statistics and Statistical Analysis System software. SEMs were calculated taking the complex sample design into account, as described in page 168 of Reference 1. Mean values for serum ferritin were calculated after logarithmic transformation because the values approach a log-normal distribution. The significance of differences between means was estimated by "Student's" *t* test.

The estimation of 95% confidence limits for relative prevalence of a depression in Hb concentration was based on the fact that mean and median values for Hb were virtually identical. We therefore assumed that the 95% range around the median Hb values in the screened population was equivalent in magnitude to the ± 2 SE range around the mean. The 95% range in relative prevalence was then derived from the Hb percentiles of the original, unscreened group that corresponded to the assumed 95% confidence limits around the median Hb in the screened population.

Results

Reference values for Hb concentration

Median Hb values (50th percentile) and the limits of the 95% range for all races,

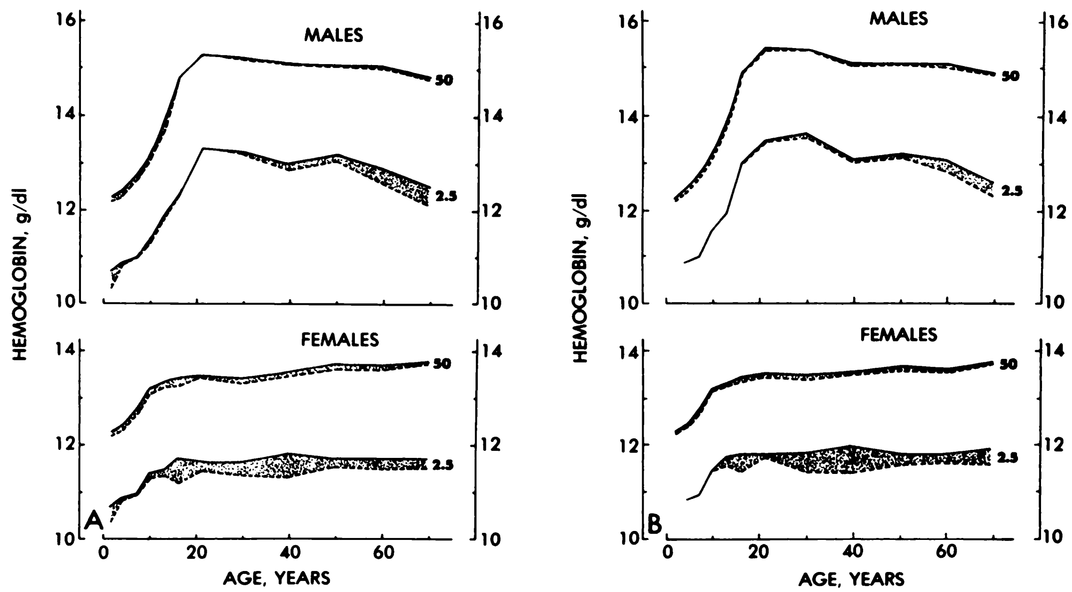

FIG 1. Hb curves for the 2.5th and 50th percentiles. The *dashed lines* represent subjects with complete data for Fe/TIBC, MCV, and EP. The *solid lines* represent the values after excluding subjects with abnormal values for these tests. The change after exclusion is shown in gray. *A* shows data for all races and *B* for whites. *B* does not show 2.5 percentile values for infants 1 to 2 yr of age because there were fewer than 100 subjects in the after exclusion group.

whites, and Blacks in the screened NHANES II reference population (see "Methods") are shown in Table 3. The developmental increase in values during childhood and the further rise in concentrations during adolescence in the male are in general accord with previously published values (2, 3, 7). With increasing age in the adult, there was a slight rise in concentration of Hb in women and a substantial decline in men. The 95% range broadened in the elderly of both sexes but particularly in men. For the purposes of this report, the values listed for all races will be considered as reference values. The values for all races and for whites were very similar; Blacks accounted for only 12% of the total weighted population. However, in accordance with previous studies (12), there was a lower median Hb concentration in Blacks than in whites that varied from 0.4 g/dl in children between 3 and 5 yr of age to 1.1 g/dl in men between 65 and 74 yr of age. The possible reasons for the difference in concentration of Hb and the extent to which it is due to genetic, socioeconomic, or dietary factors are important and complex issues but ones that requires more detailed analysis than is possible in this report.

The Hb reference ranges derived from NHANES II corresponded closely with the results of large surveys conducted in Sherbrooke, Canada (13) and in Finland (14). These surveys, as well as NHANES I (1971 to 1974) (15), also showed a broadening of the Hb range in the elderly and a decline in mean Hb values in elderly men. The NHANES II Hb concentrations for children were slightly lower (by 0.1 to 0.4 g/dl) in whites than previously reported reference values that were derived in a similar manner (9). The NHANES II mean Hb values were also about 0.3 g/dl lower than the corresponding concentrations obtained in NHANES I. The basis for the discrepancy is unclear, but it does not appear to be attributable to a difference in prevalence of iron deficiency.

Prevalence of anemia: percentage of values below the 95% reference range

The percentage of individuals with Hb values below the reference range is shown according to age and sex on Table 1. The

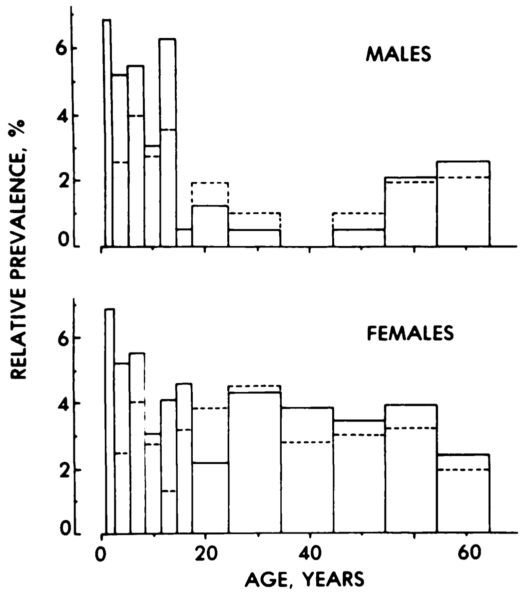

FIG 2. Relative prevalence of a depression in Hb concentration due to iron deficiency or inflammatory disease. The values were derived from the shift in median Hb concentration after excluding individuals with abnormal values for FE/TIBC, MCV, or EP. The *solid bars* represent relative prevalence for all races and the dashed bars represent relative prevalence for whites.

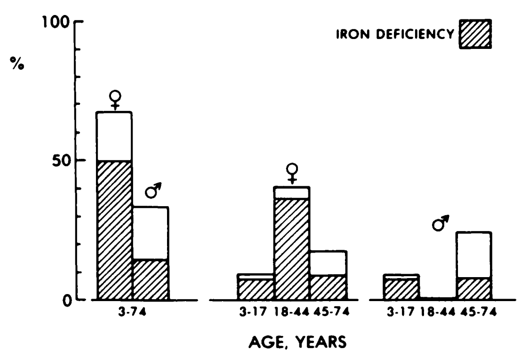

FIG 3. Severe and moderate anemia: characteristics of the 52 subjects who had a Hb concentration below 10.0 g/dl. The percentage of anemic subjects with iron deficiency (see "Results") is indicated by cross-hatching.

highest prevalence of anemia for all races was in infants 1 to 2 yr of age (5.7%), girls 15 to 17 yr of age (5.9%), young women (4.5%), and elderly men (4.8%). The lowest prevalence of anemia was in children 6 to 8 yr of age (2.3%) and in males 12 to 44 yr of age (2.6 to 2.9%). Since the prevalence of anemia was no higher than 6% in any group, it is important to keep in mind the fact that the definition of anemia (a value below the 95% reference range) would lead one to expect a value of about 2.5% even in an entirely healthy population. When the same calculation is applied only to whites, using the 95% reference ranges for whites shown in Table 3, the results were very similar.

Relative prevalence of a depression in Hb concentration due to iron deficiency and chronic disease

Relative prevalence of a depression in Hb concentration was calculated from the change in the median Hb concentration when subjects with Fe/TIBC <16%, MCV <80 fl, *or* EP >75 μg/dl red blood cells were excluded (Fig 1). The percentile curves shown are the 50th (median) and the 2.5th (lower limit of the 95% range) for all races. The exclusion of subjects who did not meet the screening criteria resulted in a substantial rise in Hb concentration at the 2.5th percentile, particularly in young women and elderly men: increases of 0.5 and 0.4 g/dl, respectively. The rise in Hb at the 50th percentile did not exceed 0.2 g/dl in any age/sex category. There was virtually no shift at either the 2.5th or 50th percentile in young men. The after-exclusion curves shown in Figure 1 are equivalent to the reference values for the median and lower limits of normal in Table 3, except that for the sake of simplicity the subgroups comprising the ages between 18 to 44 and 45 to 64 yr are combined in Table 3.

The relative prevalence of a depression in Hb concentration due to anemia and inflammatory disease was highest (6.8%) in infants between 1 and 2 yr of age (Fig 2). It declined in children between 3 and 5 yr (5.3%), 6 and 8 yr (5.5%), and 9 and 11 yr of age (3.1%). In adolescence, values rose to a peak in boys between 12 and 14 yr (6.3%) and in girls between 15 and 17 yr of age (4.6%). Between 18 and 24 yr of age, values were low in both men (1.4%) and women (2.2%). Subsequently, values in men remained below 1% until 55 to 64 and 65 to 74 yr, when they increased to 2.1 and 2.6%, respectively. Young women had values near 4.0% until 65 to 74 yr of age, when relative prevalence decreased to 2.4%.

The 95% confidence limits around the

estimates of relative prevalence were calculated as described in "Methods." In general, this range around the percentage relative prevalence approximated ± 1%. For example, the ranges for women 25 to 34 yr and men 65 to 74 yr of age were 3.5 to 5.1% and 1.2 to 3.7%, respectively.

Different patterns of laboratory abnormalities in anemic subjects according to age and sex

The pattern of laboratory abnormalities of anemic subjects in those groups with a high relative prevalence of anemia suggested differences in the predominant etiology of the anemia. Mean values for several laboratory tests in infants between 1 and 2 yr old, in women 25 to 44 and men 65 to 74 yr of age are shown in Table 2. For each of these groups, laboratory values are shown for those whose concentration of Hb was in the anemic range compared to those with a Hb concentration above the lower limit of the reference range for age and sex (Table 3). In infants, young women, and elderly men, those who were anemic had lower Fe and Fe/TIBC, and higher EP values than the remaining group; the MCV was significantly depressed in the infants and young women but not in the elderly men. From these results alone, it was difficult to distinguish between iron deficiency and inflammatory disease as a major basis for anemia in each group (2, 3). However, the results of the TIBC and serum ferritin gave some indication of the relative contribution of the two conditions. TIBC is often depressed in individuals with inflammatory disease, infection, or protein deficiency, whereas it is elevated in many individuals with iron deficiency (2, 3). Serum ferritin is depressed in iron deficiency but typically elevated in inflammatory disease (2, 3). The mean TIBC was significantly elevated ($p < 0.01$) in anemic infants and young women but not in the anemic elderly men. The serum ferritin was depressed in the anemic young women ($p < 0.01$) but not in the elderly men with anemia (no serum ferritin analyses were done in children under 3 yr old). These results indicate that iron deficiency was predominant as a cause of anemia in the infants and young women but that anemia seemed more commonly related to inflammatory disease and perhaps other conditions in elderly men.

Prevalence and causes of moderate or severe anemia

Moderate or severe anemia was rare in NHANES II. Only 52 (0.3%) of the 17,795 subjects above the age of 3 yr in whom Hb was analyzed had a Hb concentration less than 10 g/dl. Although the survey was not designed to look at individuals, some interesting relationships were suggested. All of the 17 anemic males were either children or adults above the age of 45 yr. In contrast, most of the 35 anemic females were between the ages of 18 and 44 yr (Fig 3).

Iron deficiency predominated among the identifiable causes of anemia (Fig 3). We defined iron deficiency in this anemic group on the basis of serum ferritin <12 μg/l or TIBC >450 μg/dl (2) (abnormalities that are characteristic of iron deficiency but not of inflammatory disease) *and* an abnormal result for either EP or Fe (>75 μg/dl red blood cells or <50 μg/dl, respectively, results that may also be characteristic of inflammatory disease) (2). By this definition, six of the 14 men (43%) and 22 of the 30 women (73%) in whom there were complete enough laboratory data were iron deficient. The predominance of iron deficiency was even more pronounced below the age of 45 yr; 21 of the 26 (81%) in this age group (both sexes) were iron deficient. In contrast, among 18 anemic subjects who were 45 yr or older, the criteria for iron deficiency were met by only eight, or less than half. Most of the subjects who did not meet the rather stringent criteria for iron deficiency, nevertheless, had some laboratory evidence of either iron deficiency or inflammatory disease. Only one subject had a Hb <10 g/dl attributable to a hemoglobinopathy, Hb SC.

Discussion

The analyses of Hb-related data from NHANES II provide information pertaining to a carefully selected representative sample of the population in the United States. Consequently, the results are helpful for deriving normative data for Hb and in delineating

the degree to which iron deficiency and inflammatory disease influenced the concentration of Hb among various age/sex groups. Such data are helpful in developing rational routines for the laboratory detection of these conditions. The information also provides a base-line on which to study future trends in prevalence of anemia, iron deficiency, and inflammatory disease. In addition, the NHANES II data are useful as a background for public health policy decisions that pertain to the fortification of foods with iron.

The reference values listed in Table 3 and depicted by the *solid lines* in Figures 1*A* and *B* show the anticipated normal rise in Hb values during childhood and the divergence in male and female concentrations starting in adolescence (3, 7, 9). The data for adult males are of interest in showing a definite peak in Hb concentration in the early twenties with a gradual decline thereafter to median values that were 1.0 g/dl lower in the oldest age group (Fig 1). Concurrently, the Hb range broadened, particularly among the elderly (Table 3). In women, the median values rose about 0.3 g/dl after about 40 yr of age; there was also a broadening of the range in the elderly but not to the marked degree seen in men.

The basis for low Hb or hematocrit values among elderly men is uncertain, as discussed in a recent paper by Lynch et al (16). One distinct possibility is a decrease in an androgen stimulation of erythropoiesis that began during puberty. Another hypothesis proposed by Lipschitz et al (17) is that anemia in otherwise healthy, aged subjects may indicate an overall reduction in hematopoietic reserve.

The application of Hb reference values to elderly men will strongly influence the percentage that are considered anemic. Application of the same criteria for anemia to adult men of all ages might result in classifying a very large percentage of elderly men as anemic. Until there is strong evidence to the contrary, it seems reasonable to apply age-specific reference standards to elderly men. In contrast, the lower limit of the reference range remains almost constant in women, making it practical to use the same criterion for anemia at all adult ages.

The apparent predominance of iron-deficiency anemia among children, adolescents, and women during the child-bearing years is in accord with previous data (2, 3). Increased iron requirements for rapid growth predispose to iron deficiency in children. In women, menstrual blood loss and the iron losses associated with pregnancy are major factors. Hallberg et al (18) have described a marked decline in prevalence of anemia among women in Sweden from 30% in 1965 to 7% only 10 yr later. He estimated that 7 to 8% of this decline could be attributed to fortification of food with iron, (the level of fortification in cereal products is about three times as high in Sweden as in the United States), 10% to the increased use of iron tablets, 3 to 4% to the increased use of oral contraceptive tablets, and 3% to the increased intake of ascorbic acid (which enhances iron absorption). By Hallberg's criteria, (Hb <12.0 g/dl), 8.8% of women 25 to 44 yr of age in NHANES II were anemic, very similar to the prevalence of 7% in Sweden at about the same time.

Both anemia and depression in the concentration of Hb related to iron deficiency and chronic disorders in NHANES II were less common than might have been anticipated from earlier surveys (19, 20). However, the oversampling of poverty groups in those surveys makes it difficult to draw conclusions about trends in the United States. The populations most affected in NHANES II were children, young women, and elderly men. The pattern of laboratory abnormalities indicated that iron deficiency was the major cause of the anemia in infants and young women, but that inflammatory disorders played a greater role in the elderly. The prevalence of either anemia or a depression in Hb concentration was well below 10% in all groups. This finding is in general accord with the more limited data available from NHANES I (15). It is difficult to make direct comparisons of NHANES I and II results because a number of laboratory tests, procedures, and quality control routines underwent changes between the two surveys; however, this will be the subject of a separate report from the National Center for Health Statistics. The results of NHANES II show that children and young women will continue to be the primary targets of efforts to

decrease the prevalence of iron deficiency. In contrast, it cannot be anticipated that such efforts will have much influence on anemia in the elderly, which may prove to be more closely related to the state of general health and to socioeconomic conditions.

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